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to say, with Mr. Corder, that I did not remark in this spot. I observed it merely as a dark spo with the *same* instrument which to-day shows me of this remarkable object in so striking a manner.

From a knowledge of the time occupied by the the spots, I think it would be safe to say that the gr was not many months old when seen by Mr. Cor Terby in 1872.

This rule seems to apply also to the equatorial bel darker portions would therefore appear to be new or formations.

Mount Hamilton:
1891 *September* 30.

Observations of the Spots and Markings on the Planet Jupiter, made with the Twelve-inch Equatoreal of the Lick Observatory.

By E. E. Barnard.

I have already communicated a series of observations and measurements of the markings on the planet *Jupiter* to the Royal Astronomical Society. I have continued these observations this year, and herewith present the results.

The planet has been extremely interesting at this opposition, from the remarkable amount and variety of detail displayed upon his surface. As usual, the two hemispheres have been strongly contrasted in their individual markings. In the southern hemisphere, besides the great red spot, new red spots have appeared, and a great number of round white spots have been visible. These objects are characteristic of the southern hemisphere, though individual white spots have at rare intervals been seen in the northern hemisphere. In the northern half of the planet a system of small dark spots has appeared. These have extraordinary short periods of rotation. The northern regions have also exhibited many features of detail. These have, however, been dark and obscure.

The great red spot has regained much of its former distinctness both in colour and form.

Observations have been made of the relative light and size of the four satellites. These will be continued. The fourth satellite seems to vary considerably in its light.

The following observations and remarks are the result of an examination of the planet with the 12-inch equatoreal of this observatory. The times are Mount Hamilton mean time.

The transits have been obtained by bisecting the equatorial belts by a vertical micrometer wire, and noting when the object passed behind this wire.

In the tabulation of the measures, N means distance from north limb of the planet, and S the reverse.

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ong Dusky Spot in the Southern Hemisphere.

	Transit	λ	N.	N. 5·20	S.	S. 5·20
	h m	°	″	″	″	″
	11 17·4	214·4	...	...	...	...
4	6 51·3	208·3	35·7	28·1	10·1	8·0
8	10 11·2	209·9	...	...	...	...

ct. 4 the length of this object was 1″·7, and its breadth ark at first, it gradually assumed a tinge of red. On t date, a very small spot closely preceded it. Its longitude inishes about 0°·47 daily.

Small Black Spots in the Northern Hemisphere.

In 1880, during October and November, it will be remembered, a number of remarkable black spots broke out on a fine linear belt just north of the equatorial belts. These objects were possessed of an extraordinary relative motion. After many singular and remarkable transformations, they finally formed a diffused red belt about the planet.

During the present year, a number of small dark spots have appeared in identically the same location. They also have an extraordinary velocity of rotation. With the exercise of a good deal of care, I have succeeded in identifying certain of these spots, and have observed them at different transits..

Following are the observations of these interesting markings. They are all located in the same latitude:—

Spot a.

	Transit	λ	N.	N. 5·20.	S.	S. 5·20.
	h m	°	″	″	″	″
1891 Sept. 17	8 51·4	244·9	16·0	12·3	31·5	24·2
21	11 1·6	205·9	...	...	...	...
Oct. 2	12 6·2	97·9	...	...	...	...

This is the following of three.

Spot b.

	Transit.	λ
	h m	°
1891 Sept. 28	7 45·3	58·7
Oct. 4	11 3·1	0·2
5	6 42·8	353·2
7	7 45·0	331·4

The following of three.

Spot c.

	Transit.	λ
	h m	°
1891 Sept. 28	7 0·9	31·9
Oct. 2	9 15·7	354·7
7	7 9·2	309·8

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The first of three.

Spot d.

	Transit.	λ
	h m	°
1891 Oct. 4	9 38·8	309·3
7	6 30·2	286·3

This is an isolated spot.

Following are transits of a few more of these dark spots which I have not identified with certainty at successive observations, though some of them may be identical:—

	Transit.	λ	
	h m	°	
1891 July 11	14 0	285·0	Isolated spot.
Sept. 3	7 59·7	268·1	The first of three.
18	10 19·5	88·4	The first of three. Perhaps the first of a chain of spots.
Oct. 4	6 46·6	205·3	The second of two isolated spots.
5	7 24·3	18·1	First of a chain of dark spots.

All the foregoing spots are located on a narrow belt in the northern hemisphere, the position of which on September 9 was

Distance from North limb = 14″·8 one obs.
Distance from South limb = 32·9 one obs.

The spots extend in a broken chain around the planet and have a relative motion (when referred to Marth's Meridian II.) of 9°·80 daily. They complete a revolution around *Jupiter* in about 37 days. They were first seen by me.

The New Oblong Red Spot in the Southern Hemisphere.

The history of this object dates from last year. It rather rapidly formed near the great red spot, as an oblong dusky marking in the first part of August 1890. Like the other new red spot now visible on the southern hemisphere, its first appearance near the great spot might suggest some connection with that object and their origin.

Its longitude diminishes about 0°·54 daily. It is clearly defined and of a strong red colour—by far the most noticeable object on the planet. Its period of revolution around *Jupiter* is about 667 days, or less than two years, as referred to the great red spot. Its motion may be slightly variable. About 1892, June 1, it will again pass the red spot, skirting the southern edge of that object at its nearest approach.

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	Transit.		λ	S.	S. 5·20	N.	N. 5·20.	Length.	L. 5·20.
	h	m	°	″	″	″	″	″	″
1891 July 13	12	44	179·6	11·3	9·5	32·2	27·1	8·4	7·0
25	12	33	177·2	11·1	9·0	33·7	27·4	9·3	7·6
30	12	25·4	168·3	10·8	8·6	33·8	27·0	10·1	8·0
Aug. 1	13	5·9	169·8	...	...	...	...	...	...
9	9	35·4	165·9	...	...	...	...	...	...
21	9	15·7	158·6	...	...	...	...	...	...
23	10	52·8	158·4	11·7	9·0	34·9	26·8	...	...
28	9	54·4	155·1	11·5	8·8	34·6	26·5	...	...
Sept. 7	8	2	151·5	...	...	...	...	...	...
16	10	17·3	146·3	11·2	8·6	34·5	26·5	...	...
18	11	51·9	144·2	11·4	8·8	34·7	26·7	...	...
Oct. 3	9	3·8	137·7	...	...	...	...	...	...
6	6	32·1	136·9	11·0	8·7	34·6	26·7	...	...

The apparent breadth of this object on July 25 was 0″·8.

There was a small white spot at its preceding end throughout the observations.

The Large White Spots in the Southern Hemisphere.

I have observed several of these objects. Their rotation periods are about the same as those of the new red spots. Their longitudes decrease about 0°·6 daily.

Spot A.

	Transit.		λ	N.	N. 5·20.	S.	S. 5·20.
	h	m	°	″	″	″	″
1891 July 27	12	46	125·9	...	...	...	...
29	14	16	121·0	...	...	...	...
Aug. 1	11	48	122·7	...	...	...	...
8	12	26·5	118·7	...	...	...	...
10	13	58	114·9	35·4	27·7	9·6	7·6
23	9	35·7	111·8	36·2	27·8	10·6	8·1
25	11	11·1	110·0	...	...	...	...
Sept. 16	8	53·5	95·6	35·6	27·4	10·3	7·9
18	10	32·0	95·9	...	...	...	...

Spot B.

	Transit.		λ	S.	S. 5·20.	N.	N. 5·20.
	h	m	°	″	″	″	″
1891 Aug. 12	12	40	8·6	...	...	...	...
20	9	4·6	1·6	10·1	7·8	36·7	28·2
27	9	42·1	357·4	10·9	8·4	36·4	27·9
Sept. 8	Transit not obsd.			10·6	8·1	36·6	27·9
17	11	41·1	347·4	11·3	8·7	35·7	27·5

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This was a very luminous spot, which passed close, skirting the southern edge of the great red spot. Measurements were made of its position to detect any displacement in latitude during its passage of the red spot.

The latitude did not sensibly change, and the great spot seemed to exert no repellent force against it.

It was first seen in the first part of August, when it was taken for a satellite in transit.

Spot C.

	Transit.	λ	N.	N. 5·20	S.	S. 5·20.
	h m	°	"	"	"	"
1891 Sept. 11	8 56·5	65·5	35·8	27·4	10·3	7·8
16	7 54·7	60·2	36·7	28·2	9·4	7·2
Oct. 3	6 35·2	48·0	...	...	...	...

This object has a peculiar wisp of dusky matter extending southwards from it.

Long Red Spot in Southern Hemisphere.

	Transit.	λ	Length.	L. 5·20.
	h m	°	"	"
1891 Sept. 17	10 17·3	296·8	...	...
Oct. 2	7 16·0	282·5	14	11
7	6 24·3	282·7	12	10

This object was first seen some time previous to August 12, when it was south preceding the great red spot. It was then dark, with no trace of red. From August 21 it began to turn red, and by September 17 was of a strong red colour. The first two transits are rough, and the measures of its length are very approximate. It is in a latitude very slightly south of that of the southern edge of the great red spot. These remarkable red strips, now so prominent in the southern hemisphere, seem to have their origin in the region of the great red spot, where they first appear as dark markings.

The Great Red Spot.

The great red spot seems to be stationary in longitude; the motion appearing to be the same as that assigned to Marth's System II. If this is so, the following observations would indicate a probable error of $\pm 0^{\circ}{\cdot}44$ or $\pm 0^{\mathrm{m}}{\cdot}73$ in the determination of the time of transit by a single estimate.

Professor Hough, from a fine series of micrometer measures, in 1880, deduced a probable error of $\pm 0^{\mathrm{m}}{\cdot}9$ in the time of transit from a single pair of measures, and thinks the micrometer method far preferable to any method of eye-estimates. Careful eye-estimates, however, I think, should have the same value as micrometer measures for determining the lines of transit of the spots on *Jupiter*. I have had a few previous remarks on this subject in a paper on the planet, printed in No. 5 of the *Publi-*

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cations of the Astronomical Society of the Pacific. (See pp. 91–92).

The colour of the great spot has been much stronger this year, and its form more definite than for a good many years. It still remains the slowest rotating object on the planet.

I have been in hopes that some of the round white spots—so abundant in the southern hemisphere—would make their appearance in the same latitude as the red spot, so that their motion would carry them over or under it; but they seem to be confined to a region the northern limit of which is parallel with the southern edge of that spot.

One object, apparently connected with the history of the red spot, and which was a prominent feature last year, has been wholly missing during the present apparition of the planet: this was a curious reddish streak emanating from the southern edge of the equatorial belt north preceding the red spot, and which, curving southwards, passed along parallel to the equatorial belt in a preceding direction. It was a perfectly symmetrical outline of the "bay" formed north following the red spot by the equatorial belt. This was visible throughout last year, and seems to be a recurring feature, since it has repeatedly appeared and disappeared within the past twelve years, alway appearing in the same position. The "bay" referred to has been very marked this year.

Careful examination, under the best conditions this year, have shown that the dark belt south of the red spot is entirely free from the edge of that object, a clear space of about ¼″ being visible between them.

The observations seem to show that the great spot is shorter this year than in 1880, and it is perhaps broader.

Following are observations of this object:—

		Transit		λ	Apparent Length.	L 5·20	N.	N. 5·20	S.	S. 5·20
1891		h	m	°	″	″	″	″	″	″
June	3	...		...	9·5	9·1	...	...	...	...
	5	16	27·3	3·2	...	...	...	...	...	...
July	14	13	38·3	2·8	...	...	...	...	..	...
Aug.	2	14	15·0	2·0	...	...	...	...	...	...
	12	12	31	3·1	...	...	...	...	...	...
	20	9	26	2·5	...	...	...	...	...	...
	27	9	54	4·3	...	...	...	...	...	...
Sept.	3	10	37·2	3·3	...	...	...	...	...	...
	17	12	6·0	2·4	...	...	...	...	...	...
	18	7	57·4	2·5	12·7	9·8	32·2	24·7	13·3	9·8
Oct.	2	9	29·6	3·1	...	...	32·4	25·4	13·7	10·7
	5	6	57·7	2·2	...	...	...	...	...	...

Width Sept. 18 = 6″·0 (4″·7 at Δ 5·20).

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The preceding end transited 1891, June 3^d 15^h $11^m{\cdot}7$, giving $\lambda = 16^\circ{\cdot}9$.

The two principal members of the system of small dark red spots which were visible last year on the northern edge of the equatorial belt, and which I have designated as spots 1 and 2, have been regularly observed and measured this year. Though not as conspicuous as when seen in April of last year, they are very distinct, and of a deep red colour. Last year the measures did not indicate with certainty any relative motion in the two. This year, however, the distance between them has diminished considerably—about 2″. The latest observations show that the distance reached a minimum in the end of August, and seems now to be slowly increasing.

Mean distance 1890	. . .	7″·64
Mean distance 1891	. . .	5·58

I have collected my observations made of these spots this year in the following table, where Δ is the observed distance between them and Δ 5·20 the value at *Jupiter's* mean distance. The measures under the headings N and S are the measured distances from the north and south limbs of the planet.

Since the first observations of these spots in 1890 April 26, they have slowly drifted through 104° of longitude at the rate of 0°·253 daily. They will make a complete revolution about *Jupiter* in 3·9 years.

		Spot 1.	λ	Spot 2.	λ	Δ	Δ 5·20	N.	N. 5·20	S.	S. 5·20
1891		h m	°	h m	°	″	″	″	″	″	″
July	4	12 33	259·9	...	...	7·4	6·4	15·9	13·7	25·6	22·1
	28	12 9	254·1	12 43	257·2	8·2	6·6	17·7	14·2	26·8	21·6
Aug.	9	12 1	254·1	...	...	7·0	5·5	17·8	14·0	27·5	21·6
	14	...	...	11 35·1	270·2	6·5	5·1	17 7	13·8	28·5	22·2
	19	10 11·9	252·2	...	...	7·3	5·2	...	...	...	...
	24	...	...	9 41·6	265·7	6·0	4·6	...	...	...	...
Sept.	7	10 42·3	248·1	...	...	6·7	5·1	18·2	13·9	28·3	21·6
	9	...	...	12 51·1	266·6	...	...	...	...	...	...
	17	10 39	244·9	...	...	7·0	5·4	18·3	14·0	29·5	22·6
	26	...	...	11 41·1	261·6	7·3	5·7	18·6	14·5	29·3	22·7
Oct.	3	11 58·2	243·0	...	...	7·8	6·1	...	...	...	...
	4	7 42·1	238·8	8 13·1	257·5	7·2	5·7	17·7	13·9	27·6	21·8

Phenomena of the Satellites.

1891 July 11^d 13^h 39^m 6^s. Reappearance of II. from occultation. Bisection.

1891 July 27^d 12^h 53^m 43^s. Transit of II. egress. Bisection.

1891 August 10^d 13^h 59^m 24^s. Conjunction of I. and II.